NINETEENTH FUSION ENERGY CONFERENCE

SESSION OV/4

Tuesday, 15 October 2002, at 8:30

Chair: M. FUJIWARA (Japan)

SESSION OV/4: Magnetic Fusion Overview 4

Paper IAEA-CN94/OV/4-1 (presented by E.S. Marmar)

Discussion

K. Ida: If the pinch term of toroidal rotation is driven by the ITG mode, one should see a clear relation between the magnitude of the pinch term and the ion temperature gradient rather than the density gradient. Is there any clear dependence of the magnitude of the pinch term on the ion temperature gradient observed in the experiment?

E.S. Marmar: In H-mode plasmas (without ITB), there is a clear monotonic correlation between the toroidal rotation and the total stored energy in the plasma divided by the plasma current (W_{tot}/I_P) [see J.E. Rice et al., Nuclear Fusion **41** (2001) 277]. Since the temperature gradient scale length is roughly fixed in these plasmas, and the density profiles are very flat out to the transport barrier at the edge, this could imply a correlation with the ITG drive, but this has not been definitively established.

D. Frigione: When you apply central ICRH power the density rise stops and so does the impurity accumulation. Is this due to a change in the sawtooth activity?

E.S. Marmar: Adding the central heating with on-axis ICRF does not change the sawtooth dynamics. These ITB discharges have normal shear q profiles, and the sawteeth are active throughout the entire time development. In cases where on-axis heating is not applied, and the plasma density and impurities continue to build up in the core, the sawteeth do eventually stop, shortly before the barrier is lost due to radiation. In cases where the buildup is arrested with the addition of on-axis heating, the sawtooth activity continues unabated.

B. Coppi: The “accretion theory” that I have presented at previous IAEA conferences and at this one accounts for and predicted the origin of rotation at the edge and its propagation toward the center at a rate that is related to the rate of the ion thermal energy transport. The modes considered are modified ion temperature gradient driven modes. The inversion of rotation with the transition from the L to H mode was also predicted. Fasoli and Sharapov now confirm that JET experiments show a change in the direction of the phase velocity of the modes excited at the edge as predicted by the same theory. The EDA mode is preferable to the ELMy H mode, as you indicated, but it requires a higher safety factor $q_{95} \geq 3.5$. This is a problem for ITER as it would require its operation at a higher beta poloidal than presently considered. What is your suggestion to resolve the ITER dilemma?

E.S. Marmar: The restriction of EDA H mode to the range $q_{95} > 3.5$ is sensitive to the plasma shape; we have recent indications that increasing the triangularity allows access to EDA H mode at lower values of q_{95}. It may also turn out that small ELM regimes, such as those that are seen on C-Mod at higher plasma pressures, may be more applicable to future burning plasma experiments such as ITER and FIRE.

Paper IAEA-CN94/OV/4-2 (presented by T.P. Goodman)

Discussion

C.S. Chang: Your machine has a unique capability to test the relationship between the $V_{\nabla B}$ direction and the divertor strike point direction with respect to the threshold power $P_{L\rightarrow H}$. Have you done this experiment?

T.P. Goodman: We have investigated the L–H power threshold in ohmic plasmas and with low density X2 heated plasmas but have not yet investigated plasmas with X3 heating at high density in this respect.

V. Parail: Concerning the strong diffusivity of fast ions you found in TCV: how does this diffusivity compare with the thermal particle diffusivity and is it influenced by the ITB formation?

T.P. Goodman: The diffusivity of fast electrons, required to resolve the difference between the F–P calculated current drive and the measured driven current, is of the same order as the thermal diffusivity (see, for example, S. Coda, EX/W-5). It follows the expected scaling. The fast particles (≥25 keV) do not appear to be strongly influenced by the ITB formation (see S. Coda, EX/W-5, and P. Nikkola, Theory of Fusion Plasmas, Varenna (2002) (Ref. [16] of this overview)).

Paper IAEA-CN94/OV/4-3 (presented by J.S. Sarff)

Discussion

D.D. Ryutov: Could you say a few words about the ion confinement in the PPCD mode?

J.S. Sarff: The ion temperature does not change significantly during PPCD. Ions are anomalously hot in standard RFP plasmas by a poorly understood heating mechanism correlated with magnetic relaxation. This relaxation activity is suppressed during PPCD, but without a better understanding of the anomalous heating mechanism it is difficult to analyze ion confinement. If the ions are heated by electron collisions during PPCD, the ion energy confinement time is significantly larger than the global energy confinement time. Please see G. Fiksel et al., EX/P4-01, for the latest on ion dynamics in MST.

S. Ortolani: You have shown that by driving the plasma through a far transient, you can turn off temporarily the requirement for the turbulent MHD dynamo which normally sustains the profiles in steady state. Correspondingly heating and confinement improve, but, as you say, all this is inherently transient. For the future, you suggest giving up ohmic heating sustainment and proceeding to external current drive. My concern and question is: have you estimated the additional power required for steady state?

J.S. Sarff: If you mean long-pulse, steady toroidal induction plus auxiliary edge current drive, yes, we estimate the required RF power to be ~1–2 MW based on theoretical analysis of wave accessibility and damping for MST parameters. If you mean true (non-inductive) steady state, the entire current profile must be sustained. In this case, proven RF physics and technology has not established efficiency large enough for a low recirculating power reactor scenario. However, inductive current ramp-down might provide simple PPCD-like profile control in a pulsed reactor scenario. Please see a paper by Nebel and Schnack to appear in Plasma Physics for an example of this possibility.

B. Coppi: Do you have evidence of “profile consistency” in your improved confinement regime? Do you observe toroidal rotation at the edge?

J.S. Sarff: Probably not, although we have not thought to consider this possibility. The time-dependent loop voltage programming used for PPCD causes the current profile to evolve continuously. Yes, we observe toroidal rotation, in both the edge and the core.

Paper IAEA-CN94/OV/4-5 (presented by F. Romanelli)

Discussion

A.J. Becoulet: Did you take into account the bootstrap current in your determination of the LHD efficiency?

F. Romanelli: Everything is accounted for. However, the bootstrap contribution is typically very small (<10%).

K. Ida: In your talk, two examples of ITB are presented. One is the case that the size of the ITB is changing in time, and the other is the case that the size of the ITB does not change. Is there any difference in the time evolution of the q profile between these examples? Could you comment on the relation between the ITB size and the q profile by comparing the two examples?

F. Romanelli: We do not have direct q measurements. From code simulations we observe a change in the LH deposition profile in the case in which the ITB expands. We estimate a broad/hollow q profile.